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The Role of Reflection and Collaboration in the Evolution of a Rroup of Novice Secondary Education Science Teachers

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Abstract: The present article analyses the changes in practices, ideas, and attitudes proposed by a group of novice science teachers during a further education teacher training program. The research on which it is based is focused on monitoring the training program and its impact on the participating teachers. The training program has as its starting point the practical problems teachers encounter, and is developed fundamentally through team work, debates, and reflection. The study demonstrates the suitability of these procedures to facilitate change and influence the professional development of these teachers.

The Importance of Continuing Educational Support at the Novice Science Teacher Stage

Novice teachers arrive at their new school with a baggage of knowledge which comes from their individual biography and the teacher education courses they have taken (Bianchini & Brenner, 2010; Thomas & Beauchamp, 2011). This baggage constitutes their principle referent when dealing with the new situation, and they generally consider that they know enough to teach. This is accentuated in the case of secondary education teachers who are "specialists" in the subject they are going to teach. In Spain the initial formation is mainly disciplinary (4-5 years) in Biology, Physics, Chemistry, or Geography, and it is only necessary to have 180 hours of formation at this level to be qualified to teach secondary education. This formation is not linked to the school and has no relation with practice in secondary education classrooms. This implies that the only reference novice teachers have of teaching styles is what they experienced as students but never practised during their teacher training process.

Given this disciplinary nature of the formation of secondary education teachers in Spain, the reflexive practice of the teacher and the relationship with pupil's learning is almost non-existent in the official initial teaching training programs, and there is no follow-up on how the novice teacher applies it in the classroom. Clearly, this is a very narrow view of what teaching, school, and pupils signify.

According to Fullan (2002), the working conditions in most schools do not contribute to solving the problems and needs of teachers during their first years of teaching. Most studies concerning novice science teachers, agree on what are the most important problems and concerns at this stage: class discipline, pupil motivation, the pupils' different levels, evaluation, relation with parents, and class organization (Solis, Luna & Rivero, 2002; Luft & Patterson, 2002, Luft, Roehrig & Patterson, 2003; Smith, 2005; Watson, 2006; Wang & Odell, 2007; Henze el al. 2009).

Science teachers' individual responses to these problems naturally incorporate expressions of a given professional culture, which already may begin to become consolidated with these first teaching experiences. The decisions they make usually have no referents

either in their practice or in their teacher education courses that would allow them to construct a strategy from a process of reflection. This frequently leads to processes of vicarious learning, and an automated and routine construction of knowledge. It also entails the risk of professional actions which are devoid of reflective processes settling into their practice, reducing socialization to mere patterns of adaptation in order to survive in the new environment.

There is broad acceptance in studies about novice science teachers of their need for support to be able to confront the problems associated with this phase of initiation into teaching. There is also insistence on the need to demand that the corresponding administration implement improvements within teacher education in all contexts, in particular the specific and differentiated continued education of novice teachers. In the Spanish context, this is especially urgent in the case of secondary education teachers given the evident deficiencies in their initial teacher education (Esteve, 1997). There is also a call for the teacher education process to be linked to active teaching practices (Elliott, 1993). A prerequisite would be the development of processes for the analysis of that practice, in which novice teachers are understood as being autonomous professionals capable of making well-founded decisions and of adopting a researcher attitude with respect to how they teach (Carr & Kemmis, 1988; Stenhouse, 1987; Zeichner, 1983).

Any process of research into teaching practice has to start with the problems that have been generated. The problems teachers themselves identify involve their more immediate interests, and when they work on these problems they feel that they are finding meaning in their involvement with teacher education activities (Crawford, 2007; Russell & Martin 2007). Working with the teachers' practical problems allows them to observe and analyse the contexts in which these problems arise. The connections they are then able to make between the problem situations and the social, cultural, and institutional framework in which they emerge enhances the significance that resolving these situations will have on their professional development (Imig & Imig, 2006).

Reflection and collaboration constitute, in the same way as working with professional practical problems does, necessary premises for the development of the basic principles of the model of teacher-researcher. The idea of "*teachers as researchers*", emerges as part of the explanation for the quality of their teaching, and this quality in turn depends on the teachers' development of reflective skills. Each of the two facets, reflection and collaboration, implies and depends on the other in promoting professional development. Nonetheless, it is important to clarify what is meant by reflection in the present work, since it may differ in nature according to the goal that is being pursued. In the present case, reflection refers to practical deliberation and critical reflection. From our perspective, reflection takes place in a practical context, in which teachers have to exercise their judgement about the situations that arise.

In critically reflecting on their actions, science teachers can gain awareness of their underlying beliefs, models, and concepts, and contrast them against the actual results of their teaching in the light of more formalized theories (Brookfield, 2000). By means of this kind of reflection, they continue learning about teaching and about themselves as teachers. It is a case therefore of fostering a teacher model in which teachers have the capacity to reflect on their action, with the result being that they develop professional knowledge that emerges naturally from their practice, and is therefore useful, understandable, and hence relatively easy to transform (Schön, 1983). Novice science teachers possess a fledgling version of professional knowledge, and can be very receptive to innovative educational proposals since there is less resistance deriving from deeply rooted traditional experiences. Since their first teaching experiences can leave a deep imprint marking their professional future (Braund & Campbell, 2010), the possibility of educational intervention at this stage takes on especial importance (Abell, 2007).

The Case and its Context: Teacher Education Activity

The research was conducted in the context of teacher education activity itself, and was in the form of a case study (Cuesta, 2004).

Our object of study was the educational activity in the continuing teacher education program. The research design was that of a case study, in particular of a single case considering the educational activity as a whole. The teacher education program has a well-defined temporal context, as it was scheduled to cover an entire school year. In this case, the phenomenon to study is the development of the program itself. It is a case study aimed at understanding the phenomenon in its context, and at evaluating its results with respect to the participants' ideas and practices. It is evaluative in nature, since the aim was to analyze the results of a specific intervention (Yin, 1993).

This case study had the overall purpose of determining and understanding the processes of professional development promoted by a further education teacher training program. One of the most important aspects in the presentation of such a case study is the appropriate description of the case and its context (Yin, 1994). Two factors have to be considered: on the one hand, the participants in the process, and on the other, the characteristics of the training program, its principles, organization, and monitoring.

The training program was designed by a team of teacher educators (three men, three women) practising at different educational levels (four at the university level, and two at the secondary education level), and with a broad experience in teaching and research into teacher education (Cuesta, 2004; Azcárate & Cuesta, 2005; Cuesta & Azcárate, 2005; Azcárate & Castro, 2006; Rivero et al., 2011; Chamoso, Cáceres & Azcárate, 2012; Azcárate & Cuesta, 2012). They were from different fields of expertise (one from Pedagogy, one from Chemistry, one from Geology, and three from Mathematics). This team composition helped promote the school/university interaction needed for a complete view of educational reality (Zellermayer & Tabak, 2006).

The educational activity was conducted by three of the team members, in two scenarios. In both of these scenarios, there participated two science teacher educators specialized in Chemistry and Geology and one in Mathematics (the educator specialized in Pedagogy was always present as an observer in the training processes). The two scenarios comprised two groups of novice science teachers (12 teachers): one of four teachers who were teaching Biology and Geology and another of eight teachers who were teaching Physics and Chemistry. In the Spanish context, secondary education teachers are responsible for teaching just one of those four sciences.

The 12 participating science teachers held degrees of "licenciados" (equivalent to B.A.'s) corresponding to five years of university in their different areas, and had also completed the course of pedagogical education, as mentioned above, of 180 hours. They were all working in secondary schools, and were under the age of 30, and between the first and the fourth year of their careers. As adult learners, the participants in the activity therefore constituted a group of novice science teachers with a common interest – to improve their practice (Sork, 2000).

The activity was designed with the same structure and similar content for the two groups of teachers. The work carried out in the training activity could be defined as group discussion with the addition of the dynamic being maintained with the help of external advisers. The training activity was carried out in 20 presential sessions of three hours during the nine months of the school course (October-June) more or less every 15 days. In parallel, the team of educators conducted 11 work sessions in which they planned and reviewed the development of the training activity.

The focus of the process is on the real problems in the participating teachers' practice that they themselves recognized. The design and development of the activity can be synthesized in the form of three main principles:

- Coherence between the medium and the message: in the development of the activity applying those same principles on which the teachers are expected to reflect.
- Working with practical professional problems: with the teachers being the protagonists who inquire into their own problems.
- Collaboration and reflection as tools: to encourage communication and dialogue, and to share interests, expectations, and problems.

These principles underlie the teacher education model, guiding the decisions taken in the design stage and during the activities. In brief, the model is organized around the following ideas:

- Teaching practice can only be improved from within.
- The teachers themselves have to be involved in the reflection and inquiry into their practice.
- Teacher education involves the need to develop processes of analysis of practice.
- Teacher education is to be understood as a process of voluntary self-evaluation on the part of its protagonists – the teachers themselves.

To this end, both teacher educators and novice science teachers, need to commit themselves to a process of inquiry into those aspects of their teaching that are identified as being problematic, and to encourage dialogue and discussion about the practices in their actual teaching (Park & Oliver, 2008). Underlying these ideas is the realization that professional knowledge is never a finished product, but always under constant construction. Its support is peer group work, with the exchange, contrast, and triangulation of information, and reflections leading to each individual's construction of that knowledge. The development of the activity applied in the present study consisted in the analysis of the practical problems detected, the design of alternatives and their implementation in practice, and the analysis of the interventions.

Methods

The research took the form of a case study whose overall purpose was to determine and understand the professional development processes resulting from a continued education program ("the case") for novice secondary education teachers in the specialities of Physics, Chemistry, Biology, and Geology. In particular, this was a study of a single case which considered the educational activity involved holistically, and was evaluative in nature (Yin, 1994) since the objective was to analyse the results of a specific intervention. The teacher training program had a well-defined temporal context as it was scheduled to cover an entire school year. The phenomenon examined was the development of the program itself, aiming to understand the phenomenon in its context, and to evaluate its results with respect to how it affected the teachers' ideas and practices.

The analysis described in the present communication is centred on the changes proposed and developed by the teachers in the two groups of sciences. The questions for the teachers to answer were:

How did the teacher training activity impact your teaching practice, conceptions, and attitudes?

And in which area was the impact most significant?

We used several sources of evidence in the development of the activity: observations, recordings, field notes, diaries, documents, interviews, and questionnaires, corresponding to two scenarios:

The work sessions of the team of educators, 11 in total, in which the planning and reviewing of the training activity were carried out.

The training sessions with the two groups of participating teachers, 20 in total.

In both scenarios the researcher's presence was constant, so that the observations were made throughout the nine months the process lasted. The information presented in the present paper had many different data sources, but which all essentially came from two instruments:

INSTRUMENTS
Session diaries: - of the teacher educators; - of the participating teachers.
Questionnaires put to both groups of participants: - questionnaire of recapitulation; - questionnaire of self-evaluation.

Table 1: Instruments

The teacher educator session diaries were maintained conjointly by the team of teacher educators participating in each group. Later, these diaries were converted into a very useful instrument for the team to reconstruct and analyse the educational activity. The teachers' session diaries were maintained individually by each teacher (twelve) after each session. Two questionnaires were completed by the novice science teachers on finalizing the educational activity:

- One denominated "recapitulation" in which each teacher was asked to give their perception of the structure and sequence of the activities carried out during the program, and of the role taken on by both the teacher educators and the novice teachers:
- Formulating their intervention hypothesis,
- Which was understood as being a declaration of intention;
- Describing the changes they were thinking of making and the indicators of the improvements they were hoping to attain; and,
- After the action in class, reporting the real improvements and difficulties that were encountered.
- Another denominated "self-evaluation" in which they were asked their point of view on how the activities had contributed to different facets of teaching: motivation, attitudes, ideas, strategies, et cetera (Appendix A).

The data collected in the study were qualitative in nature. For their organization, it was necessary to reduce the quantity by selecting manageable units of information. The units we considered corresponded to the idea of meaningful propositions, dividing the raw data into organizational categories in order to clarify the empirical evidence and facilitate its interpretation. The mechanical processing of the data was carried out using the qualitative data analysis program NUDIST (QSR Projects, 1999).

The category system used consisted of three broad classes.

- The first was designed to include all the information needed to characterize the teacher training activity,

- The second to include the information with which to characterize the evolution of that activity, and the third to characterize the changes perceived by the participating teachers.
- It is this third category with which the present article is concerned, the objective being to detect changes in the teachers' ideas, attitudes, and professional knowledge over the course of the development of the activity. This category allows us to analyse the impact of the teacher training activity on the participants. It includes information on which aspects they questioned, and which aspects they noted as being open to change in terms of the planning and practice of their teaching, their educational ideas, and their attitudes to teaching.

Repercussions of the Educational Activity: Teacher Change

In this section, we shall characterize the changes that took place in the teachers. To analyse the possible repercussions that the educational activity had on them, we shall present in some detail the proposed changes in their practice, and then outline the evolution of their ideas and attitudes.

Changes in Teaching Practice

In this subsection, we shall analyse the proposals that the teachers designed and put into effect in their classes to attempt to overcome the problems they saw as most significant in their practice. These problems were centred on discipline, lack of interest, and attending to the diversity of the pupils. The proposals for intervention were therefore directed at trying to improve those particular situations in which these problems arose.

It has to be stressed that the changes we shall be describing are to be understood as tentative, as the teachers' were trying out hypotheses of intervention with which to have a different approach to the problem situations they encountered in their classrooms.

To be able to analyse and calibrate the reach of the modifications that the teachers designed and put into effect in their classrooms, we must first describe their prior initial methodological practices. From the teachers' own descriptions of how they taught their classes at the beginning of the activity, we can outline the most significant characteristics of their practice (Azcárate & Cuesta, 2005; Azcárate & Cuesta, 2012):

- The activities were generally taken from those proposed in the textbook, selecting those best adapted to the context.
- The structure of the commonest tasks was: explanation “application exercises” correcting.
- Their justification for the lecture style of class and for the exercises generally being done individually was that it helped maintain order in the classroom and was a means of "getting on with the subject".
- The resources most used were the blackboard and oral expression. Little use was made of the laboratory.
- The fundamental strategy they used to get the pupils to work in class was the power of evaluations and end-of-term grade.

The changes they proposed were fundamentally oriented to the search for strategies that would facilitate communication with the pupils, arouse their interest, and get them involved them in the tasks put to the class. In general, all the teachers recognized that when

the pupils were given a more relevant role they became more involved in the process.

In the following, we shall describe the proposals that some of the teachers made and put into practice to resolve the problems that they had identified. In order to describe and analyse the proposed changes, a questionnaire of recapitulation was agreed on that covered the different points for reflection: formulating their intervention hypothesis, which was understood as being a declaration of intention; describing the changes they were thinking of making and the indicators of the improvements they were hoping to attain; and, after the action in class, reporting the real improvements and difficulties that were encountered. This questionnaire allowed the results to later be contrasted in the group. The category identification reflected the themes of interest in our study, and allowed the units of information which we recognized in the data as being related to those themes to be identified and classified. The mechanical processing of the data was carried out using the qualitative data analysis program NUDIST (QSR Projects, 1999).

Here, we shall present some of the novice science teachers' reflections on the proposals designed and implemented in their classes so as to improve their practice:

One teacher, IS, saw her core problem as being her pupils' lack of interest and participation, and apathy towards her teaching. The changes she was considering in her practice involved modifying the activities she set to try to make them attractive. She expressed her proposal in her diary:

"Choice of my hypothesis: To change method in explanations and activities. I will propose open activities and encourage the deduction of ideas more than explanation on my part.

1. Description of the action: – I am going to carry out a change of method to encourage their participation more, especially when doing activities, I will set the activities in another way to encourage their interest in them. Getting their interest in the activities, the results should be more positive, and I assume that they will become more motivated and will participate more. (...)

4. Achievements: – They did not protest when the activity was set, they like working in groups more. – They were asking me how they were doing with the activity. – Their answers were better thought out than normally.

5. Difficulties encountered: – In groups, they get out of control a lot if they are close together. – In the whole-class session they do not know how to listen to each other. – There are some pupils who still do not take the activities seriously." (Teacher's session diary. Biology and Geology Group)

IS perceived improvements in the pupils' attitude with the modifications introduced, but was uncertain about the results. This is an example of not trusting her assessment of the changes that are taking place in her classroom – an attitude that appears with the first attempts at modifying habitual practices, and that constitutes an obstacle in that it puts a brake on the as yet tentative process. To overcome it, it is necessary to persevere with the initiatives for improvement, and to analyse the results and at the same time construct arguments that will sustain them.

- Another teacher, MJ, saw her problem in terms similar to those of IS. Her pupils were very passive; they did not participate; for her they were "[apathetic children]". Her proposal for improvement was a new layout of the classroom, eliminating the barrier represented by the dais, putting herself at their height to favour communication. In her session diary, MJ formulates her proposal and analyses her results:

  "Formulation of the problem: The pupils are too 'static', they do not participate actively in the class. They become bored and I become bored.

1. *Description of the action: – To change the physical organization of the class, to form a group class. – To change the method towards one that is more participative, where the pupils are able to learn by their discoveries. (...)*
4. *Achievements: The new layout allows talking together and debate, and nobody can get lost; I am more on top of things. Too much?*
5. *Difficulties encountered: – The pupils are not used to this type of work, and they don't find it easy to adapt. – Some do not participate, maybe because they feel that I am invading their vital space."* (Teacher's session diary. Biology and Geology Group)

Although she found difficulties in the different way of setting the work, she insisted with her initiative, and was able to observe the resulting improvements in her communication with the pupils and in their involvement in the activities proposed.

- For VI, the priority problem was motivation. In analysing this situation, he recognized that his pupils had little self-esteem and no confidence in their possibilities. For that reason, he decided to pass them all in one of the tests that he set them. The immediate result was that the pupils gained in confidence. In light of this experience, he decided that he had to make it part of his work to give the pupils a positive self-image – "so that they know that they are capable and that they are valued". He sets out his proposal in his session diary:

"1. Description of the action: – To modify the content so as to adapt it to the level of my pupils, and to choose that which can be of greatest interest. – To change the layout of the class. – To propose different activities related to their daily life: 'Drinks' if we continue with Chemistry, 'The Electricity Bill' or 'Making Circuits' if they decide on electricity." (Teacher's session diary. Physics and Chemistry Group)

- For CA, there existed a very clear problem with a particular class group. This consisted of pupils with very negative academic results, showing a total lack of interest, and with whom she had achieved no type of communication. She considered different possibilities of intervention, and eventually decided to change drastically the method she had been using. She decided to "avoid dwelling on the group's (negative) progress", and instead "to emphasize the advances that they achieved". Thus, in her session diary:

"2. Description of the changes: – Fewer prolonged and theoretical explanations. – Start with more procedural activities to introduce the content. – Ask the pupils' opinion about what aspects of the content of their level they would like to deal with. — Not to insist on the group's progress, highlight the advances obtained. (...)

4. *Achievements: — I have noticed greater participation on the part of certain pupils, some of whom before behaved like pieces of furniture. – Motivation has depended very much on the day and the actual activity, but there has been a slight increase in it."* (Teacher's session diary. Physics and Chemistry Group)

Initially, CA was cautiously optimistic about the possibilities of improvement in the group's situation. This optimism gradually became more positive as she observed the progress in class. At the same time, however, she became aware of how complex teaching and learning processes really are, and of the importance of trying to achieve improvements little by little, without expecting immediate changes.

CA noted that she was very happy now because she saw that the modifications seemed to have had an effect. In this sense, she commented that the program was making her

realize that she had to change the class dynamic if she wanted to do something with her pupils. (...) (Teacher educators' diary, the sessions of the Physics and Chemistry Group)

These examples are representative of the tendency of their changing methodological habits. This tendency is also reflected in their responses to the self-evaluation questionnaire (Annex 1) given at the end of the program. The questionnaire was designed to analyse what contribution the program had made to some of the aspects configuring their methodological habits in teaching. The responses showed that there had indeed been a change in the strategies they considered in order to get their pupils involved in the class, and in their view of their pupils' role in the teaching and learning process:

The strategies to stimulate your pupils' work in class.
IS: We all used more or less the same strategies, and these did not work. We must remember that the activities have to get their attention, be attractive, and fit their level.
AJ: Give them exercises that motivate them, that are neither all closed problems nor all the same, but I still have a lot left to learn.
CC: Begin by just setting up the problem, not giving solutions. Let them look for the solutions.
MJ: Before it was their marks, negative or positive, et cetera. Now, they learn because it interests them, because it is not me who evaluates them directly, or who tells them what they have to learn.
VI: To connect with their interests, awaken their interest, motivation.
AJ: Through work in the classroom we get to connect with the pupils, so that I think that we must work fluidly with them, so that there is communication to be able to resolve the problems that arise.

Thus, in order to get the pupils involved, it was considered important to evaluate what they did during the entire process, not only their examination results. It seems that evaluation then played another role, different from what they had considered before.

If the pupils are going to be the centre of classroom activities, it is necessary to stimulate communication with them. This was a constant in the teachers' ideas – to develop strategies which encourage the pupils to express themselves, and which generate a relaxed climate of work and participation:

The criteria to consider in selecting and organizing activities for your pupils.
IS: The most important is that an activity has to be concordant with the pupils' level and be attractive for them, if it connects with the pupils' interests it gets them more involved.
VI: Their level of knowledge, their interests, and their motivations.

Initially, the resources used for the activities were in most cases reduced to the blackboard and oral presentation. In their final answers, they recognized that they had broadened the range of resources accessible when giving their classes:

The set of resources that you have in mind when you are preparing and giving your classes.
MJ: Before, the resources that I used were minimal (the blackboard, textbook, and some photocopies). Now I know that I can use any resource that occurs to me. For example, for the topic of Biotechnology, I used plasticise to make a model of DNA.
CA: It is still very limited, I have a lot left to learn.

The data that we analysed reflect those aspects that the participating teachers considered to be susceptible of change in their practice. These would be changes that could be defined as tentative. They are modifications that the teacher would not have tried out if left alone, and have seen in the context of the continuing education activity, protected by the backing and aid of the group – of both their fellow novice science teachers and the accompanying teacher educators. As novice science teachers, they initially had neither the conceptual nor the procedural tools with which to undertake alone the necessary process of change that would lead to an improvement of their practice in response to the problems they encountered.

There was one common element in the changes they made in their day-to-day practice – the role they assigned to their pupils. All the changes were directed at making the pupils' active participation more relevant in the teaching-learning process. This is a first step in the evolution of their conception of education from a "teacher-centred" to a "learner-centred" approach (Conti, 2007). It is this shift to new habits, attitudes, and ideas, thus replacing the traditional concept of teaching, that give these tentative approaches the capacity to stimulate the reconstruction of a teacher's idea system.

The Changes in Ideas

With respect to the teachers' ideas, we found the most significant progress to be in the characteristics they attributed to the task of teaching. In their valuations of the program's educational activity, it was clear that the model of a teacher that they were beginning to outline differed importantly from that which they showed at the start of the process. In their final appreciations, they valued the educational activity as having allowed them to become aware of the importance of their work, and that this would form the basis of their future development as teachers.

In their valuations, they stressed the importance of:

- Planning, in its aspect of reflection on their practice.
- The analysis of their practice as a condition for its improvement.
- The attitude of critical reflection as a condition for their professional development.
- The necessity for interchange and collaboration.
- The importance of taking the pupils into account.
- Their responsibility in the improvement of education.

It is interesting to contrast these ideas with those expressed at the beginning of the program. There, we characterized the teachers' initial conceptions about education and teaching, and the practical problems that they perceived – they let the responsibility for success or failure in the educational task fall basically on the pupils. And the responsibility that they recognized as teachers was reduced to the task of "explaining". Most of the teachers considered that learning depends on the capacity and interest of the pupils. Nevertheless, they recognized that they practically teach all their pupils in the same way.

The modifications and advances in their ideas that the teachers recognized as an overall contribution of the program's educational activity are confirmed in their responses to the self-evaluation questionnaire, in which they were asked to analyse how the activity had contributed to their interpretation of different facets of teaching. They indicated that pupils' difficulties in the learning process have to be taken into account by putting oneself in the pupils' position so as to see the proposed situations and tasks from their perspective. In sum, it is a matter of recognizing that the pupil is the protagonist of the learning process. They also

recognize the importance of reflection as a tool of mutual feedback between theory and practice.

> *The criteria to consider in selecting and organizing activities for your pupils.*
> *CA: They must be such that they encourage the pupils' investigative activities. The pupils must be perfectly implicated in their learning process. Not only is it necessary to evaluate that they have studied the content, but also that it has become part of their mental structure.*
> *SS: It has above all helped me to see the need for reflection on my teaching practice to make my work effective and in accordance with our pupils' reality.*

They thus discover the sense of planning as the expression of a hypothesis of intervention that comes from interpreting teaching as a process of inquiry.

> *Your view of how to teach pupils considering the differences between them.*
> *CA: To achieve that my pupils learn what I want to transmit to them, I need to reflect and investigate much more on what I now do, before actually approaching the task.*

In general, the participating novice science teachers expressed in their responses a different way of interpreting the teaching process and the role the teacher plays in it. This was a more complex and elaborate point of view than that expressed at the beginning of the activity. There was a concomitant evolution in their attitudes to teaching.

Changes in Attitudes

The teachers' attitudes at the beginning of the activity were revealed in their descriptions of the problems they felt to be most important in their practice. As we indicated above, these problems were centred on motivation, discipline, and dealing with diversity. One in general perceived an attitude of rejection with regard to diversity and in response to the pupils' passivity and the conflictive nature of some of them. It is possible that the teachers' changes in attitude were due to the opportunity that the educational activity gave them to compare and contrast their views and practices with their peers. This enabled them to broaden their field of view, and at the same time allowed them to establish more elaborate and complex relationships between the different factors involved in the problems they were facing, and to design and test alternative ways of approaching them. Nevertheless, it must not be forgotten that this evolution was only possible because of their initial readiness, in spite of everything, to inquire into and look for possible solutions to the problems they recognized in their practice. Given this attitude, it was then possible for them to recognize their own deficiencies and limitations without this being a cause of inhibition. On the contrary, it allowed them to accept their responsibilities, and encouraged them to act.

In their responses to the self-evaluation questionnaire, there were references to an overall change in attitude about their professional future. This was a conscious change, recognizable in their practice, in the form they confronted different situations, and in their reactions to those situations.

> *Your view of how to teach pupils taking into account the differences between them.*
> *CC: We have to 'have fun' teaching, we have a lot of years ahead and it would be horrible to have to 'put up with' a boring job.*

Change was also supported by the positive feedback the teachers' perceived from their actual improvement in class, with the creation of a positive self-image as they found they had an ever greater capacity for intervention and self-reliance in overcoming the difficulties that they had encountered.

Your motivation for teaching.
SS: It has helped me to be more motivated with respect to overcoming the problems that arise, and to investigating how to improve my work.

They need collaboration and interchange as the context to facilitate the emergence of positive attitudes and to provide the channel for their development. They can thus share problems and concerns, obtain support, gain confidence, et cetera.

Your interest in exchanging experiences and communicating with other teachers.
MJ: Very positively, since before, when I spoke with colleagues at the school, what we did was complain and not look for solutions. The interchange with other teachers has helped me to confront problems and look for solutions to them.

As one appreciates in the participants' responses, resistance to change is evidently not a distinctive characteristic of the attitudes of this group of teachers. This is clear not only in their questionnaire responses, but also in their active involvement in the development of the educational activity, in their questioning their own practices and ideas, and in their sharing with the other participants what they do and what they think.

Factors that Facilitate Change: Implications for Science Teacher Education

Our intention with this study has been to identify the changes that the novice science teachers experienced during the course of the educational activity. The analysis has allowed us to investigate some of the factors that favoured the processes of conceptual progress and the development of the task of teaching. These factors were found to be: *the teachers' recognition of their own practical problems, a positive attitude to tackling them, and the dynamic of collaboration.*

Problems arise in the professional practice of novice science teachers which they are insufficiently prepared to deal with. The conscious *recognition of these problems* is the fundamental step towards "cracking open" and questioning the pre-existing system of ideas and practices. Although novice teachers have evident problems generated by the unfamiliarity of their professional practice, they have the advantage of being susceptible and open to change, so that it is more feasible for them than for an experienced teacher to look for and implement alternatives. The fact that these teachers perceived significant situations in their practice as "problems" we believe to be one of the keys to understanding the influence of the educational activity in which they participated". It was also the key to activating the process of their professional development. The idea behind the educational activity of the program was that the teachers should question and reconstruct their professional thinking and practice (Rivero et al., 2011).

Together with the teachers' recognition of their practical problems, another of the factors that we considered key to explaining the impact of the educational activity was *the attitude that they showed.* Although they essentially attributed the causes of their problems to external factors, they demonstrated their interest in proposing solutions and in involving themselves in the improvement of the conditions in which they were teaching. And it was this attitude that facilitated their becoming aware of the need to learn new conceptual and procedural tools. The processes of change are diverse and complex. If a person "does not want to", then change is impossible. The pre-condition for change is not just a case of "being ready", it is also a question of "willingness" – a personal predisposition to accept the questioning of one's own sense and view of oneself as a professional. Interesting in this sense is Rudduck's reflection (1994:391) on the processes of change:

"One must understand that, with respect to both institutions and individuals, some degree of resistance to change has to be expected (...) These are typical defence mechanisms of complex systems. (...)."

Recognition of the importance of personal and affective factors means that they must not be neglected or minimized in teacher education processes. Many workers have observed the major role played by teachers' personal, emotional, and affective aspects in the processes of change (Hargreaves, 1994; Broadhead, 1995). Harnessing the potential of positive attitudes has to be a fundamental premise in the planning and development of educational activities. In particular, this would mean encouraging the idea that the construction of a new image should be on the basis of the old, facilitating the transformation by providing referents as the specific supports necessary in the initial stages of change when new meanings are being constructed.

The dynamic of interaction with colleagues in the group was another of the aspects most appreciated by the participants, due to their being able to share experiences and problems with their peers as a channel for the development of the educational process. We therefore consider this *dynamic* to be another of the keys to the positive influence of the activity, as indeed it is known to be an aspect which affects the process of professional development (Tillema & Van der Westhuizen, 2006). Dialogue functioned as a strategy of reflection, allowing meanings to be confronted and reconstructed (Azcárate & Castro, 2006; Chamoso, Cáceres & Azcárate, 2012). For the teachers, sharing with their colleagues the new experiences they were trying out in their classrooms was important. Group support encouraged them to keep going, and generated an atmosphere of collaboration and complicity among the group members. This atmosphere propitiated a type of interaction in which the teacher educator's role was that of maintaining the dynamism of the activity, facilitating the process, helping with the identification of problems and the analysis of situations, contributing ideas and information to the design of possible plans for intervention and improvement, etcetera. In sum, the protagonists were the participants themselves, not the educators.

Processes of change in general are non-linear – they are personal and as diverse as the individuals who participate. To respond to this diversity, the strategy behind the educational activity can be neither linear nor closed. Indeed, it was precisely the creation of a cohesive group that both made it possible for the participants to respond suitably to individuality in their classes and stimulated their personal changes.

Final Valuation

The educational activity of this continuing teacher education program was based on the interests, problems, and form of thinking and acting of the participant novice science teachers. This design allowed them to inquire in some depth into the practical problems they identified, to reflect upon them, to look for their causes, to put forward explanatory hypotheses, and to contrast their experiences and explanations with their colleagues. They were thus naturally constructing a richer, and more complex and elaborate, theoretical framework on the significance of teaching. At the same time, they were trying out different forms of action in their classrooms, and reflecting together on their results. This allowed them to progress to more conscious forms of exercising their profession.

The processes of change, as we have observed above, have an inherent complexity that prevents their being associated with simple generalizations. Indeed, it is difficult to establish precisely either their ultimate reach or their primary causes. We have, however, been able to begin to understand how these changes took place in the particular context of an

educational activity with this group of novice teachers. And we were able to confirm the premises and principles of action that allowed all the participants to make progress from their initial level. We are aware that the processes of change are personal and idiosyncratic, and that the personal and professional dimensions of those involved are complex and difficult to study. Nevertheless, our analysis of the changes that were observed in the novice science teachers over the course of the educational activity allows us to give a positive overall valuation of the influence of this activity on their professional development. We consider that the significance of this influence in explaining and understanding these changes suggests the importance of persisting with the design and development of this type of educational activity for the continued support and counselling of teachers.

Research on teachers' professional development reveals that their learning is a complex process in which multiple factors intervene, with an interrelation of the individual, the social, and the organizational. In this sense, the integration of reflection, collaboration, and the development of communities of practice begin to *characterize a model of teacher education* with which to help enhance one's understanding of how teachers learn.

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Appendix A: Self-Evaluation

Teacher of: Physics and Chemistry…
Biology and Geology…

Analyse the contributions of the program in the facets mentioned.

1. Your motivation for teaching.
2. Your attitude to reflection about work in the classroom.
3. Your interest in exchanging experiences and communicating with other teachers.
4. Your readiness to continue developing professionally in the future.
5. Your desire to go deeper into the didactics of your subject, and to incorporate new pedagogical knowledge into your teaching practice.
6. Your ideas about the applications that the knowledge you usually develop in your classes might have in everyday life.
7. Your view of how pupils learn and whether or not they all do so in the same way.
8. Your view of how to teach pupils considering the differences between them.
9. Your view of how to connect with the pupils' interests in the classroom.
10. The strategies you might use to detect the pupils' previous ideas and knowledge on a given topic.
11. How you use the pupils' previous ideas and knowledge on a given topic.
12. The criteria that you might use in selecting content for your classes.
13. The set of resources that you have in mind when you are preparing and giving your classes.
14. The strategies to stimulate your pupils' work in class.
15. The criteria to consider when selecting and organizing activities for your pupils.
16. The possible evaluation instruments you have available.
17. The utility that you might assign to the data obtained in an evaluation.